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EP 560026
US 5323088

ABSTRACT

A controlled switching device which is suitable for use as a lamp dimming controller and which is arranged to be connected to an alternating current supply. The device comprises two parallel-connected solid state switching elements (13 and 14) which are arranged to be connected in current conductive relationship with a load such as an electric lamp (10). A control circuit (15) is provided and arranged to apply time spaced gating signals to the respective switching elements (13 and 14) during each half-cycle of the supply, the time interval between the gating signals being small relative to the half-period of the supply. A current limiting element (21) is located in circuit with the switching element (13) (which is the first to be gated during each half-cycle of the supply) and which provides an impedance to current flow during the time interval between the gating signals.

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AUSTRALIA

Patents Act 1990

ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Invention Title: CONTROLLED SWITCHING DEVICE

The following statement is a full description of this invention, including the best method of performing it known to us:

GH REF: P04210-UR/RW:SD

This invention relates to a controlled switching device. The invention has been developed in the context of a lamp dimming controller and is hereinafter described in that context. However, it will be understood that the invention does have broader application, to other circuits such as fan speed control circuits in which phase-angle controlled switching of current to a load is required.

Lamp dimmer control circuits conventionally include a solid state switching device, typically a triac, and a control circuit for generating a gating signal and for varying the phase angle at which the gating signal is applied to the switching device. A filter network normally is also incorporated in the dimmer control circuit for minimising the possibility of radio frequency interference due to radiation of high frequency harmonics that are generated as a consequence of phase angle-controlled switching of the supply.

The lamp dimmer control circuits normally are connected in circuit with on-off light switches and are mounted to switch mounting plates. This means that they must be compact and that the filter components in particular should be as small as possible. The filter components in a typical lamp dimmer control circuit comprise a 0.033 μF, 240 volt working capacitor and a 100 μH, 2 amp rated inductor.

However, in the interest of reducing further the effect of radio frequency noise, regulatory authorities are imposing limits on the allowed power level of radio frequency emissions over a broad spectral range. This in turn has created a requirement for large filter circuit components, and such components cannot conveniently be located within the space which currently is available behind standard small size switch mounting plates.

The present invention seeks to meet this problem by providing a controlled switching device which functions in use to generate high frequency harmonics at a lower average power level than that which is attributable to

equivalent prior art devices and which, as a consequence, facilitates the use of smaller-size filter circuit components.

Thus, the present invention provides a controlled switching device which is arranged to be connected to an alternating current supply and which comprises at least two parallel-connected solid state switching elements which are arranged to be connected in current conductive relationship with a load. A control circuit is provided for applying time spaced gating signals to the respective switching elements during each half-cycle of the supply, the time interval between the gating signals being small relative to the half-period of the supply. Also, a current limiting element is located in circuit with the switching element which is first gated during each half-cycle of the supply and which provides an impedance to current flow during the time interval between the gating signals and, hence, gating of the respective switching elements.

The current limiting element may comprise a reactive element but preferably comprises a resistor.

The time interval between gating of the respective switching elements is preferably selected to be less than 1.0 mS and most preferably will be selected to be in the order of 0.05 to 0.20 mS.

It has been found that, by gating the switching elements at spaced-apart times and by introducing circuit impedance during the time interval between gating of the respective switching elements, the transient voltage rise that normally accompanies gating in a circuit having reactive components is reduced and, as a consequence, the power level of radio frequency noise is reduced. Also, filtering of the radio frequency noise is enhanced due to the fact that two-stage filtering is effectively performed during each half-cycle.

The control circuit of the switching device, which may be embodied in a microprocessor, would normally include means for varying the phase angle at which gating

is effected, although the invention does have application to circuits in which gating is effected at a fixed (constant) phase angle during each half-cycle of the supply.

The controlled switching device may have any selected number of switching elements located in parallel or series-parallel configurations, depending upon the intended application of the invention, but for most practical applications, including application of the device to lamp dimming control, the device will include two only switching elements.

The invention will be more fully understood from the following description of a preferred embodiment of a lamp dimming control circuit. The description is provided with reference to the accompanying drawings in which:

Figure 1 shows a circuit diagram of the complete circuit for connection to a single phase supply,

Figure 2 shows the waveform of voltage across a lamp during one complete cycle of the supply, and

Figure 3 shows a generalised form of the lamp dimming control circuit of the type shown in figure 1.

As illustrated, the dimmer control device is connected to a single phase ac supply and in circuit with an incandescent lamp 10. Power supply to the lamp is varied by controlling current to flow during a selected portion of each half-cycle of the supply, and consequential radio frequency emission is minimised by filtering higher order Fourier components of the resultant waveform by way of a filter network comprising a capacitor 11 and an inductor 12.

As indicated previously, current flow control is achieved in prior art dimmer control devices by locating a single triac in series with a lamp and by gating the triac into conduction for a selected period during each half-cycle of the supply. In contrast, in the preferred embodiment of the present invention as illustrated, two parallel-connected triacs 13 and 14 are connected in circuit with the lamp 10 and an associated control

circuit 15 is arranged to apply a gating signal to the triac 13 before a gating signal is applied to the triac 14.

As a consequence of effecting serial gating of the two triacs 13 and 14, transient voltage spikes that normally would be generated due to the presence of the reactive filter components 11 and 12, are reduced in amplitude. This has the effect of reducing the power level of Fourier harmonics of the waveform which is shown in Figure 2 and which results from switching of the triacs.

The gating signals for the triacs 13 and 14 are generated within the control circuit 15 and, as illustrated, the control circuit comprises a voltage divider network comprising resistor 16 and a diac 17 connected in parallel with a capacitor 18. A potentiometer 19 is connected in circuit with the capacitor 18 to provide a variable time constant for the circuit and, hence, to provide for variation of the phase angle at which the triac 13 is gated. A further diac 20 is located in the gating circuit and provides for a gating pulse to be applied to the triac 13 when the capacitor 18 is charged to the breakdown voltage of the diac.

A resistor 21 is located in series with the triac 13 and performs two functions. That is, it limits current flow through the triac 13 and provides effectively a voltage supply for a further RC network comprising resistor 22 and capacitor 23. An SBS 24 is connected in the gating circuit associated with the triac 14 and is arranged to provide for a gating pulse to be applied to the triac when the capacitor 23 is charged to the breakdown voltage of the SBS. The various components in the gating circuit of the triac 14 are selected to provide for gating of the triac upon expiration of a predetermined time interval, typically 0.1 mS, following gating of the triac 13.

A capacitor 25 and a series resistor 26 are

connected across the two triacs and in series with the lamp 10, for the purpose of obviating or minimising any flickering that might occur in the lamp due to the generation of back emf in the inductor 12.

Figure 2 shows two half-cycles of the voltage waveform that appears across the lamp 10 during operation of the circuit and with the potentiometer 19 adjusted to a position which causes gating of the triac 13 at a phase angle of approximately 45°. As indicated previously, triac 13 is first gated at the selected phase angle, and the second triac is then gated after expiration of the predetermined time interval. Current flow through the lamp 10 is limited by the resistor 21 following gating of the triac 13 and pending gating of the triac 14.

The values and, where appropriate, product identification numbers are shown as follows as being appropriate to a dimmer control circuit which is connectable to a 240 volt single phase supply which is required to power a lamp load falling within the range 40 watts to 300 watts.

Inductor	12	700 μH
Triac	13	TICP206M
Triac	14	BT137-500
Resistors	16	68K, 1 watt
	21	33 ohms, 1 watt
	22	2.7K
	26	730 ohms
Potentiometer	19	500K
Capacitors	11	0.22 μF, AC 240v (MKP 336 2)
	18	0.04 μF, 50v
	23	0.10 μF, 25v
	25	0.10 μF, AC 240v (MKP 336 2)
Diacs	17	DB 6, 64v
	20	DB 3, 32v
SBS	24	MBS 4991-4993, 8v

It will be understood that the circuit values and

component identifications provided above are typical only and may be varied to meet specific requirements and applications of the circuit.

Variations and modifications may be made in respect of the invention as above described. For example, the various circuit elements incorporated within the control circuit 15 as shown in Figure 1 may be replaced by a microprocessor 27, and the circuit resistor 21 as shown in Figure 1 may be replaced by a reactive circuit element 28, both of which modifications are indicated in Figure 3.

The claims defining the invention are as follows:

1. A controlled switching device which is arranged to be connected to an alternating current supply and which comprises at least two parallel-connected solid state switching elements which are arranged to be connected in current conductive relationship with a load, a control circuit which is arranged to apply time spaced gating signals to the respective switching elements during each half-cycle of the supply, the time interval between the gating signals being small relative to the half-period of the supply, and a current limiting element located in circuit with the switching element which is first gated during each half-cycle of the supply and which provides an impedance to current flow during the time interval between the gating signals.

2. The controlled switching device as claimed in claim 1 wherein there are two only switching elements and wherein the time interval between the gating signals applied to the first and second switching elements is determined by the control circuit to be less than 1.0 mS.

3. The controlled switching device as claimed in claim 2 wherein the time interval between the gating signals applied to the first and second switching elements is determined by the control circuit to fall within the range 0.05 mS to 0.20 mS.

4. The controlled switching device as claimed in any one of claims 1 to 3 wherein the time interval between the gating signals is fixed by parameters within the control circuit.

5. The controlled switching device as claimed in claim 2 or claim 3 wherein the time of applying the gating signal to the first switching element following commencement of each half-cycle of the supply is selectively variable.

6. The controlled switching device as claimed in claim 5 wherein the time of applying the gating signal to the first switching element is selected by varying the value of the resistive component of an RC timing network

within the control circuit.

7. The controlled switching device as claimed in any one of the preceding claims wherein an LC filter network is located in circuit with the switching elements.

8. The controlled switching device as claimed in any one of the preceding claims wherein the switching elements comprise triacs.

9. The controlled switching device as claimed in any one of the preceding claims wherein the current limiting element comprises a resistor.

10. The controlled switching device as claimed in any one of claims 1 to 5 wherein the control circuit is constituted by a microprocessor.

11. The controlled switching device as claimed in any one of claims 1 to 10 wherein the solid state switching devices are arranged to be connected in current conductive relationship with a load in the form of an electric lamp.

12. The controlled switching device substantially as shown in Figures 1 and 2 or Figure 3 of the accompanying drawings and substantially as hereinbefore described with reference thereto.

DATED this 25th day of February 1997
H.P.M. INDUSTRIES PTY LIMITED
By their Patent Attorneys
GRIFFITH HACK

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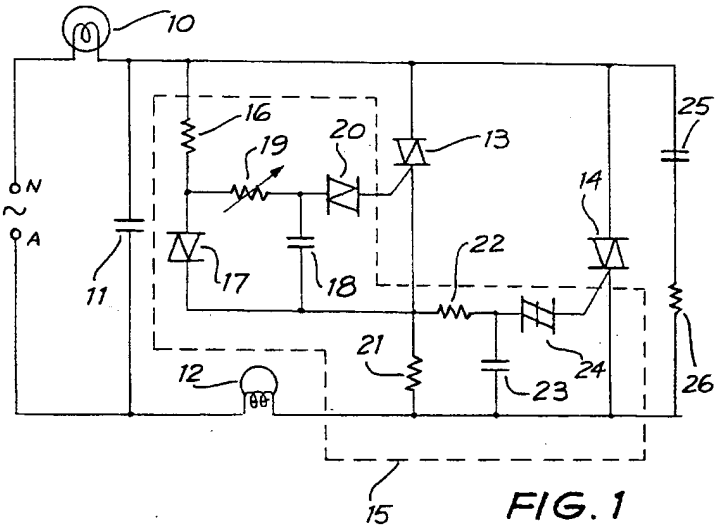

FIG. 1

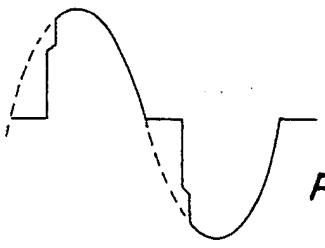

FIG. 2

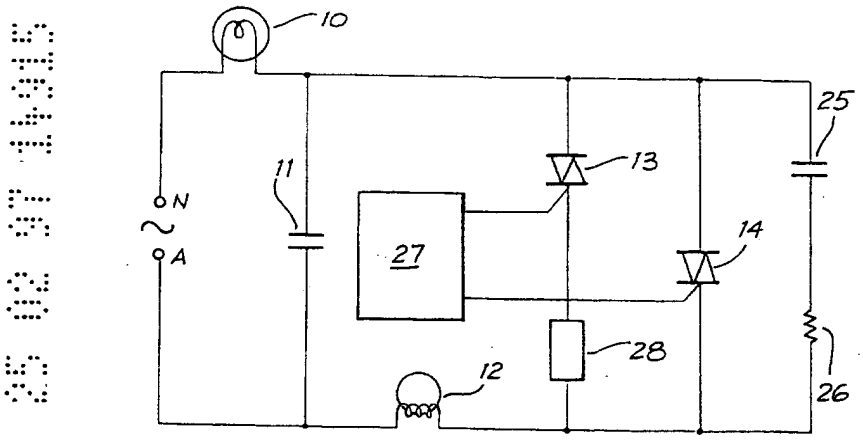

FIG. 3